SL Paper 1

Two waves meet at a point in space. Which of the following properties always add together?

A. Displacement

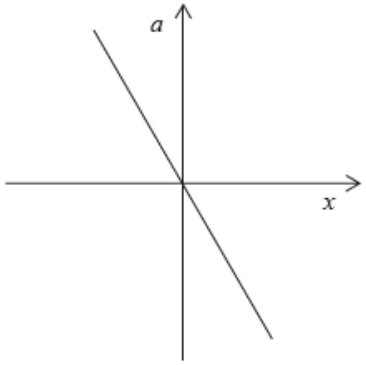
B. Amplitude

C. Speed

D. Frequency

Which graph correctly shows how the acceleration, a of a particle undergoing SHM varies with its displacement, x from its equilibrium position?

A.



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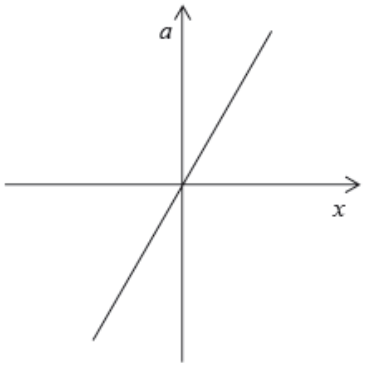

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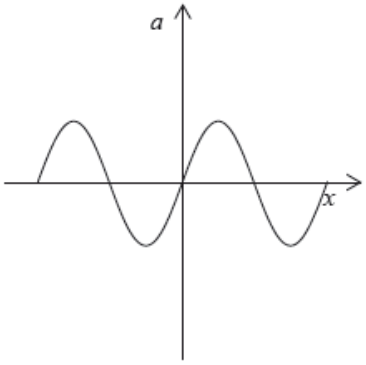

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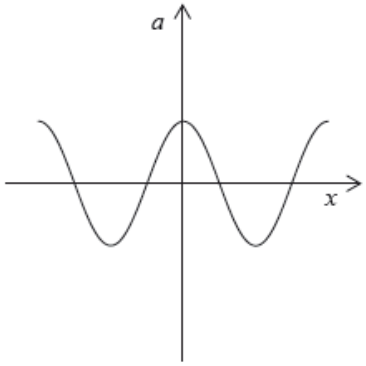


A transverse travelling wave has an amplitude x_0 and wavelength λ. What is the minimum distance between a crest and a trough measured in the direction of energy propagation?

A. $2x_0$

B. x_0

C. λ

D. $\frac{\lambda}{2}$

A point source emits sound waves of amplitude *A*. The sound intensity at a distance *d* from the source is *I*. What is the sound intensity at a distance 0.5*d* from the source when the source emits waves of amplitude 2*A*?

A. 16*I*

B. 4*I*

C. *I*

D. $\frac{1}{4}I$

In which of the following regions of the electromagnetic spectrum is radiation of wavelength 600 nm located?

A. microwaves

B. radio waves

C. visible light

D. X-rays

A student stands a distance *L* from a wall and claps her hands. Immediately on hearing the reflection from the wall she claps her hands again. She continues to do this, so that successive claps and the sound of reflected claps coincide. The frequency at which she claps her hands is *f*. What is the speed of sound in air?

A. $\frac{L}{2f}$

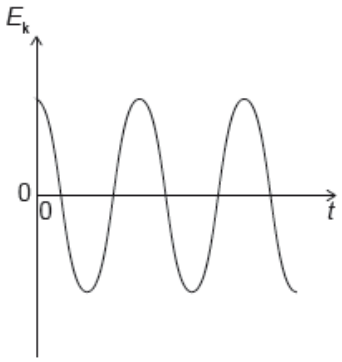
B. $\frac{L}{f}$

C. *Lf*

D. 2*Lf*

A particle is displaced from rest and released at time *t* = 0. It performs simple harmonic motion (SHM). Which graph shows the variation with time of the kinetic energy E_k of the particle?

A.



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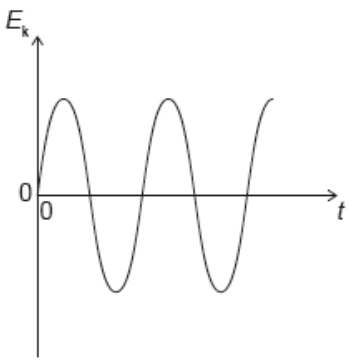

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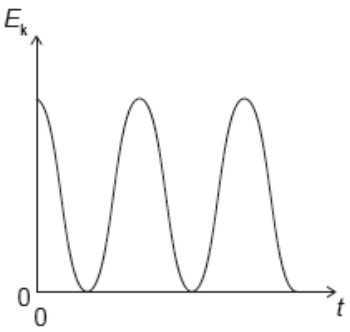
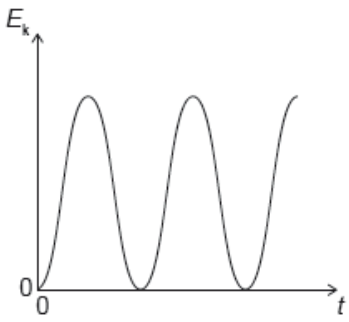


D.



What is the phase difference, in rad, between the centre of a compression and the centre of a rarefaction for a longitudinal travelling wave?

A. 0

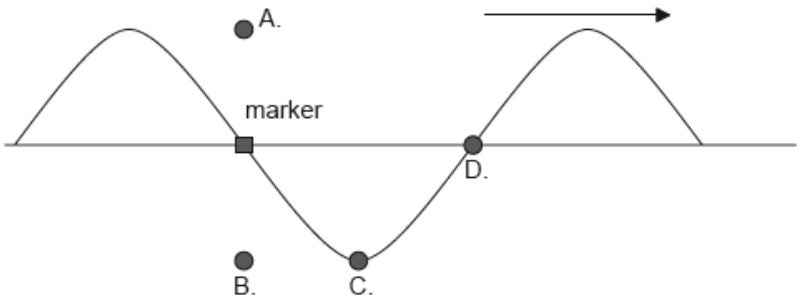
B. $\frac{\pi}{2}$

C. π

D. 2π

A wave on a string travels to the right as shown. The frequency of the wave is f. At time $t = 0$, a small marker on the string is in the position shown.

What is the position of the marker at $t = \frac{1}{4f}$?



Electromagnetic waves

A. always obey an inverse square law.

B. are made up of electric and magnetic fields of constant amplitude.

C. always travel at the same speed in a vacuum.

D. are always polarized.

The frequency of the first harmonic standing wave in a pipe that is open at both ends is 200 Hz. What is the frequency of the first harmonic in a pipe of the same length that is open at one end and closed at the other?

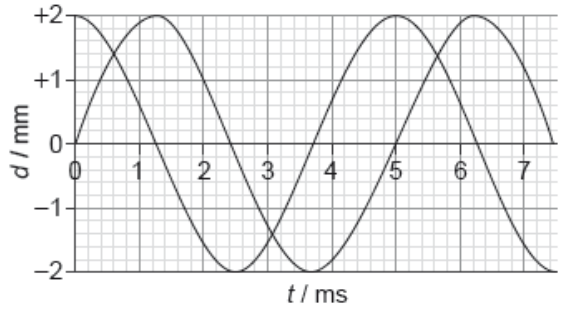
A. 50 Hz

B. 75 Hz

C. 100 Hz

D. 400 Hz

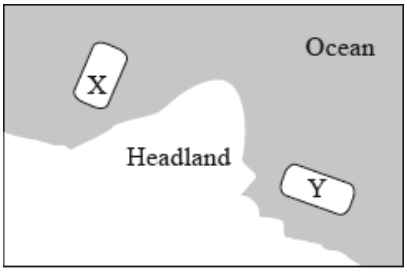
Two travelling waves are moving through a medium. The diagram shows, for a point in the medium, the variation with time *t* of the displacement *d* of each of the waves.



For the instant when *t* = 2.0 ms, what is the phase difference between the waves and what is the resultant displacement of the waves?

	Phase difference	Resultant displacement / mm
A.	45°	−0.6
B.	90°	2.6
C.	45°	2.6
D.	90°	−0.6

An orchestra playing on boat X can be heard by tourists on boat Y, which is situated out of sight of boat X around a headland.



The sound from X can be heard on Y due to

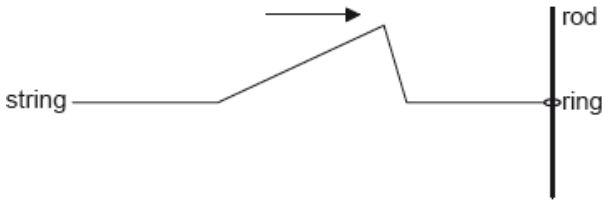
A. refraction.

B. reflection.

C. diffraction.

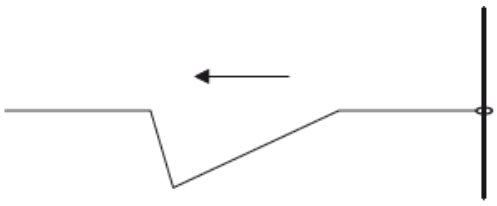
D. transmission.

A wave pulse travels along a light string which is attached to a frictionless ring. The ring can move freely up and down a vertical rod.



What is the shape of the wave pulse after reflection?

A.



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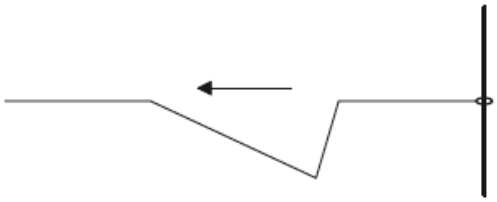

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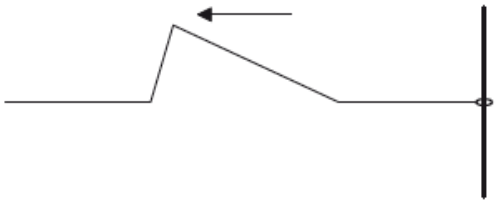
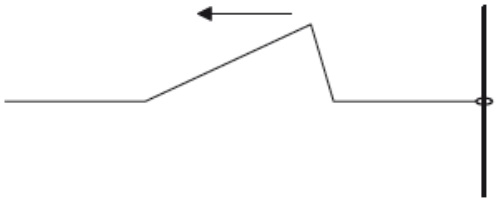


D.



A pipe of length L has two open ends. Another pipe of length L' has one open end and one closed end.

The frequency of the first harmonic of both pipes is the same. What is $\frac{L'}{L}$?

A. 2

B. $\frac{3}{2}$

C. 1

D. $\frac{1}{2}$

Two identical waves of wavelength λ leave two sources in phase. The waves meet and superpose after travelling different distances. Which path difference will result in destructive interference?

A. $\frac{\lambda}{4}$

B. $\frac{\lambda}{2}$

C. $\frac{3\lambda}{4}$

D. λ

Which of the following gives regions of the electromagnetic spectrum in the order of **decreasing** frequency?

A. gamma-ray, microwave, visible
B. radio wave, infrared, microwave
C. ultraviolet, infrared, microwave
D. visible, gamma-ray, radio wave

Which of the following is a value of wavelength that is found in the visible region of the electromagnetic spectrum?

A. $4 \times 10^{-5}\ \mathrm{m}$

B. $4 \times 10^{-7}\ \mathrm{m}$

C. $4 \times 10^{-9}\ \mathrm{m}$

D. $4 \times 10^{-11}\ \mathrm{m}$

For a body undergoing simple harmonic motion the velocity and acceleration are

A. always in the same direction.
B. always in opposite directions.
C. in the same direction for a quarter of the period.
D. in the same direction for half the period.

In simple harmonic oscillations which two quantities always have opposite directions?

A. Kinetic energy and potential energy

B. Velocity and acceleration

C. Velocity and displacement

D. Acceleration and displacement

The power emitted as electromagnetic radiation by the Sun is approximately 4×10^{26} W. The radius of the orbit of Mars around the Sun is approximately 2×10^{11} m. What is the best estimate for the power incident on an area of 1 m^2 at the radius of Mars' orbit?

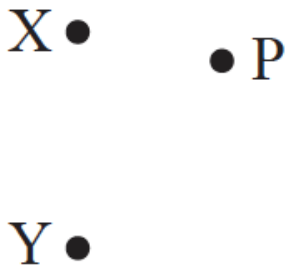
A. 10^3 W
B. 10^7 W
C. 10^{11} W
D. 10^{15} W

The intensity of radiation from a star at the surface of one of its planets is *I*. The distance between the star and the planet is *d*.

What is the intensity at the surface of another planet which is a distance $\frac{d}{4}$ from the star?

A. 4*I*
B. 8*I*
C. 16*I*
D. 64*I*

Waves emitted from sources X and Y have equal wavelengths and are initially in phase. The waves interfere destructively at point P, where the path difference is 0.60m.



What is a possible value for the wavelength of the waves?

A. 0.20 m
B. 0.30 m
C. 0.40 m
D. 0.60 m

A girl in a stationary boat observes that 10 wave crests pass the boat every minute. What is the period of the water waves?

A. $\frac{1}{10}$ min

B. $\frac{1}{10}$ min^{-1}

C. 10 min

D. 10 min^{-1}

What statement about X-rays and ultraviolet radiation is correct?

A. X-rays travel faster in a vacuum than ultraviolet waves.

B. X-rays have a higher frequency than ultraviolet waves.

C. X-rays cannot be diffracted unlike ultraviolet waves.

D. Microwaves lie between X-rays and ultraviolet in the electromagnetic spectrum.

A pipe of fixed length is closed at one end. What is $\frac{\text{third harmonic frequency of pipe}}{\text{first harmonic frequency of pipe}}$?

A. $\frac{1}{5}$

B. $\frac{1}{3}$

C. 3

D. 5

The refractive index for light travelling from medium X to medium Y is $\frac{4}{3}$. The refractive index for light travelling from medium Y to medium Z is $\frac{3}{5}$.

What is the refractive index for light travelling from medium X to medium Z?

A. $\frac{4}{5}$

B. $\frac{15}{12}$

C. $\frac{5}{4}$

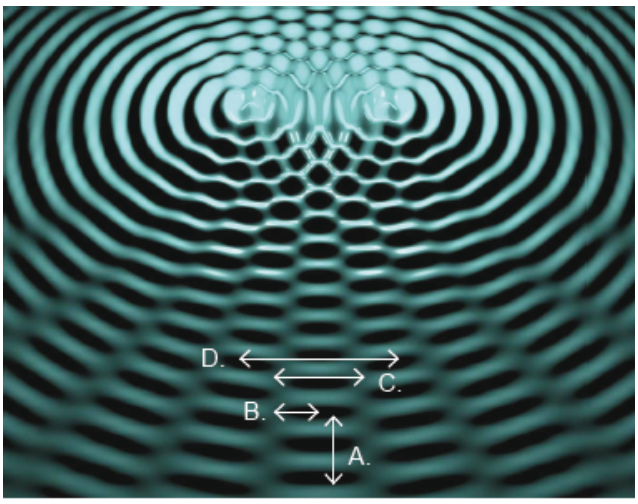
D. $\frac{29}{15}$

A body undergoes one oscillation of simple harmonic motion (shm). What is correct for the direction of the acceleration of the body and the direction

of its velocity?

A. Always opposite
B. Opposite for half a period
C. Opposite for a quarter of a period
D. Never opposite

The diagram shows an interference pattern produced by two sources that oscillate on the surface of a liquid.



[Source: Science Photo Library www.sciencephoto.com]

Which of the distances shown in the diagram corresponds to **one** fringe width of the interference pattern?

Two sound waves from a point source on the ground travel through the ground to a detector. The speed of one wave is 7.5 km s^{-1}, the speed of the other wave is 5.0 km s^{-1}. The waves arrive at the detector 15 s apart. What is the distance from the point source to the detector?

A. 38 km

B. 45 km

C. 113 km

D. 225 km

A pair of slits in a double slit experiment are illuminated with monochromatic light of wavelength 480 nm. The slits are separated by 1.0 mm. What is the separation of the fringes when observed at a distance of 2.0 m from the slits?

A. 2.4×10^{-4} mm

B. 9.6×10^{-4} mm

C. 2.4×10^{-1} mm

D. 9.6×10^{-1} mm

What is true about the acceleration of a particle that is oscillating with simple harmonic motion (SHM)?

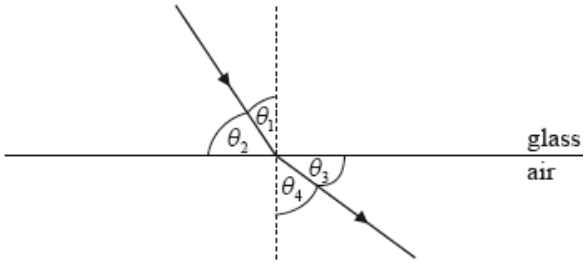
A. It is in the opposite direction to its velocity

B. It is decreasing when the potential energy is increasing

C. It is proportional to the frequency of the oscillation

D. It is at a minimum when the velocity is at a maximum

A ray of light is incident on a boundary between glass and air.



Which of the following is the refractive index of glass?

A. $\frac{\sin\theta_1}{\sin\theta_3}$

B. $\frac{\sin\theta_1}{\sin\theta_4}$

C. $\frac{\sin\theta_3}{\sin\theta_2}$

D. $\frac{\sin\theta_4}{\sin\theta_1}$

A system that is subject to a restoring force oscillates about an equilibrium position.

For the motion to be simple harmonic, the restoring force must be proportional to

A. the amplitude of the oscillation.

B. the displacement from the equilibrium position.

C. the potential energy of the system.

D. the period of the oscillation.

What are the changes in the speed and in the wavelength of monochromatic light when the light passes from water to air?

	Change in speed	Change in wavelength
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

A sound wave has a wavelength of 0.20 m. What is the phase difference between two points along the wave which are 0.85 m apart?

A. zero

B. 45°

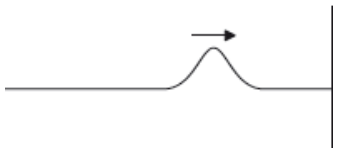
C. 90°

D. 180°

Monochromatic light travels from air into water. Which of the following describes the changes in wavelength and speed?

	Wavelength	Speed
A.	increases	decreases
B.	increases	increases
C.	decreases	increases
D.	decreases	decreases

One end of a horizontal string is fixed to a wall. A transverse pulse moves along the string as shown.



Which of the following statements are correct for the reflected pulse compared to the forward pulse?

I. It moves more slowly.

II. It has less energy.

III. It is inverted.

A. I and II only

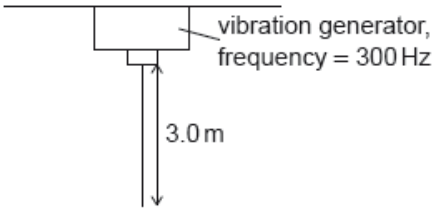
B. I and III only

C. II and III only

D. I, II and III

A first-harmonic standing wave is formed on a vertical string of length 3.0 m using a vibration generator. The boundary conditions for this string are that it is fixed at one boundary and free at the other boundary.

diagram not to scale



The generator vibrates at a frequency of 300 Hz.

What is the speed of the wave on the string?

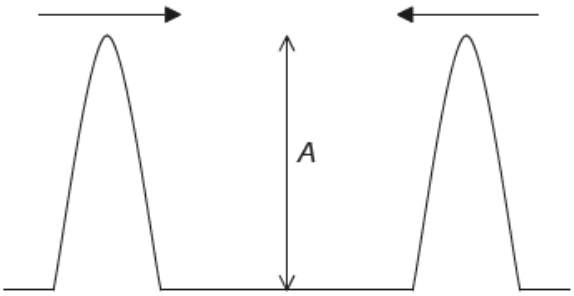
A. 0.90 km s^{-1}

B. 1.2 km s^{-1}

C. 1.8 km s^{-1}

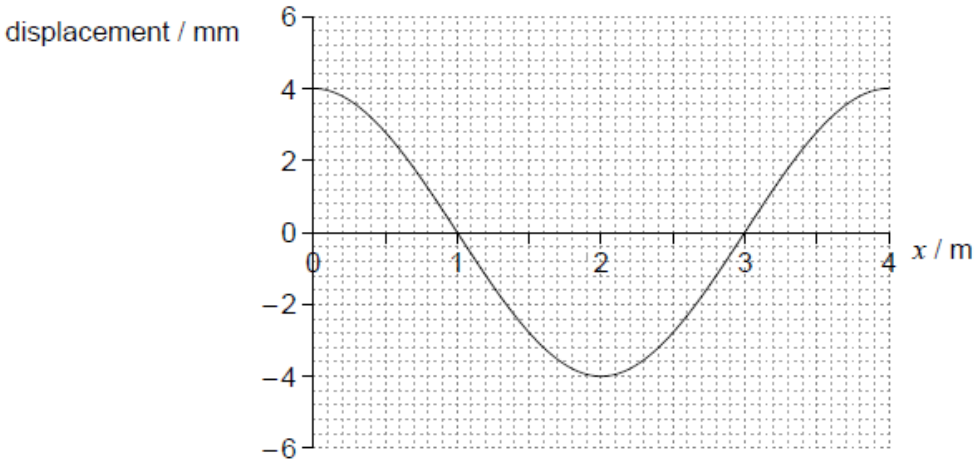
D. 3.6 km s^{-1}

Two wave pulses, each of amplitude *A*, approach each other. They then superpose before continuing in their original directions. What is the total amplitude during superposition and the amplitudes of the individual pulses after superposition?



	Total amplitude during superposition	Individual amplitudes after superposition
A.	*A*	less than *A*
B.	*A*	*A*
C.	2*A*	less than *A*
D.	2*A*	*A*

The graph shows the variation with distance *x* of the displacement of the particles of a medium in which a longitudinal wave is travelling from left to right. Displacements to the right of equilibrium positions are positive.



Which point is at the centre of a compression?

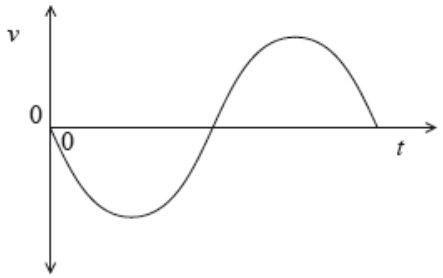
A. $x = 0$

B. $x = 1$ m

C. $x = 2$ m

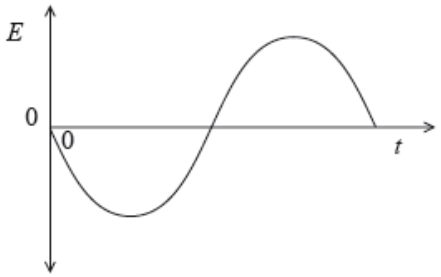
D. $x = 3$ m

The graph shows how the velocity v of an object undergoing simple harmonic motion varies with time t for one complete period of oscillation.

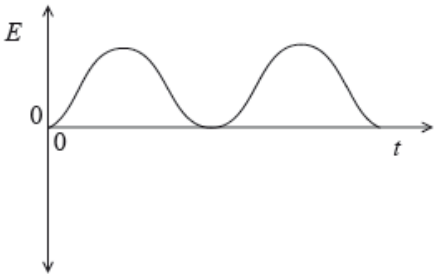


Which of the following sketch graphs best shows how the total energy E of the object varies with t?

A.



B.



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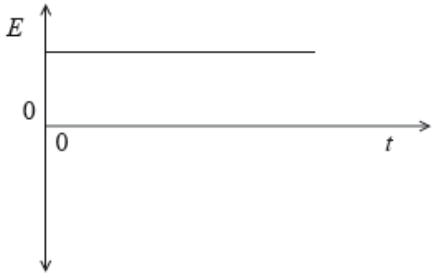
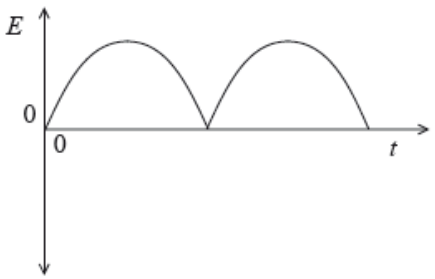


D.



A high solid wall separates two gardens X and Y. Music from a loudspeaker in X can be heard in Y even though X cannot be seen from Y. The music can be heard in Y due to

A. absorption.

B. diffraction.

C. reflection.

D. refraction.

What region of the electromagnetic spectrum includes waves of wavelength 5×10^{-8} m?

A. X-ray

B. Ultraviolet

C. Infrared

D. Microwave

An object performs simple harmonic motion (SHM) about a central point. The object has velocity *v* and acceleration *a* when it has displacement *x* from the point.

Which ratio is constant?

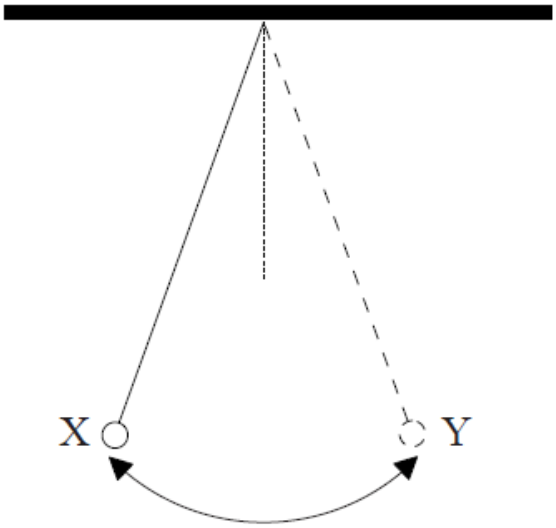
A. $\frac{x}{a}$

B. $\frac{x}{v}$

C. $\frac{x^2}{a}$

D. $\frac{v}{a}$

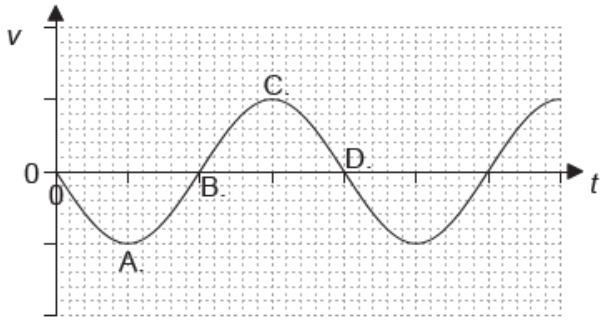
A pendulum swings back and forth in a circular arc between X and Y.



The pendulum bob is

A. always in equilibrium.
B. only in equilibrium at X and Y.
C. in equilibrium as it passes through the central position.
D. never in equilibrium.

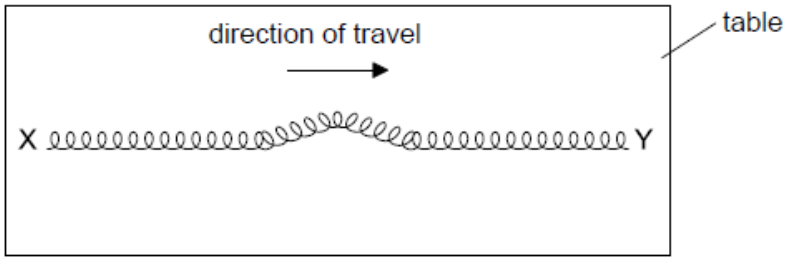
The graph shows the variation with time *t* of the velocity *v* of an object undergoing simple harmonic motion (SHM). At which velocity does the displacement from the mean position take a maximum positive value?



Light of wavelength 600 nm travels from air to glass at normal incidence. The refractive index of the glass is 1.5. The speed of light in air is *c*. Which of the following correctly identifies the speed of the waves and their wavelength in the glass?

	Speed	Wavelength
A.	$\frac{2c}{3}$	900 nm
B.	c	900 nm
C.	c	400 nm
D.	$\frac{2c}{3}$	400 nm

A spring XY lies on a frictionless table with the end Y free.



A horizontal pulse travels along the spring from X to Y. What happens when the pulse reaches Y?

A. The pulse will be reflected towards X and inverted.
B. The pulse will be reflected towards X and not be inverted.
C. Y will move and the pulse will disappear.
D. Y will not move and the pulse will disappear.

What is the best estimate for the refractive index of a medium in which light travels at a speed of $2.7 \times 10^8\ \mathrm{m\,s^{-1}}$?

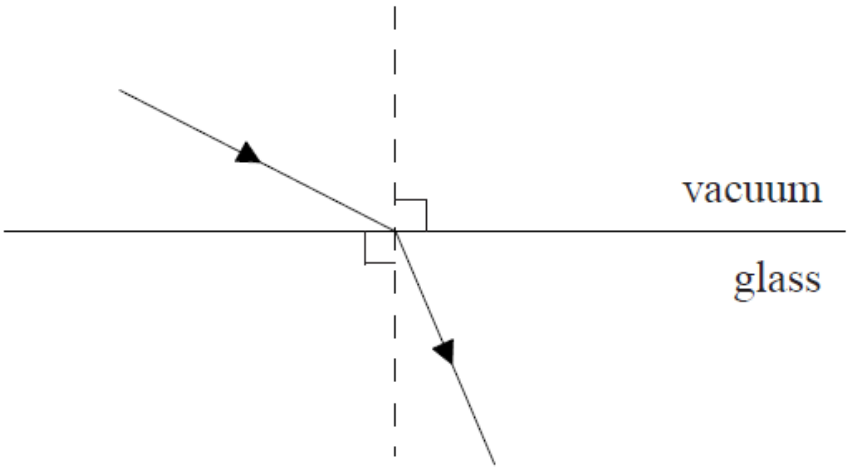
A. 0.9

B. 1.0

C. 1.1

D. 2.7

A ray of light travels from a vacuum into glass as shown below.



In glass, light has speed *v*. In a vacuum, light has speed *c*. Which of the following gives the refractive index of glass?

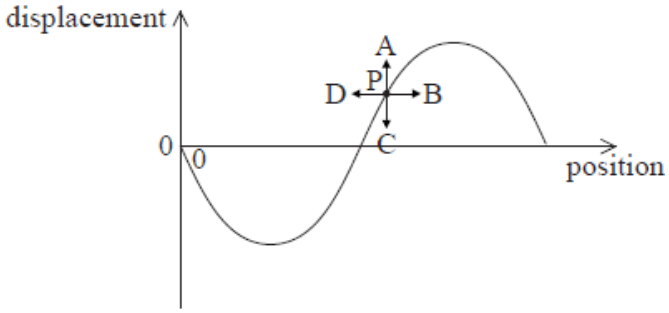
A. $\frac{c}{v}$

B. $\frac{v}{c}$

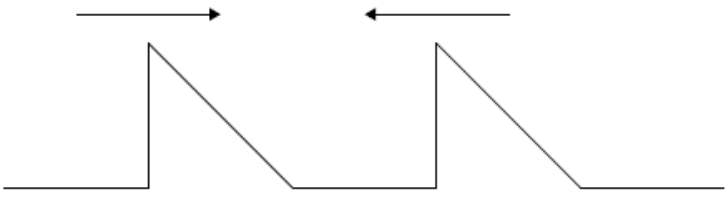
C. $\frac{\sin c}{\sin v}$

D. $\frac{\sin v}{\sin c}$

A transverse wave travels from left to right. The diagram below shows how, at a particular instant of time, the displacement of particles in the medium varies with position. Which arrow represents the direction of the velocity of the particle marked P?

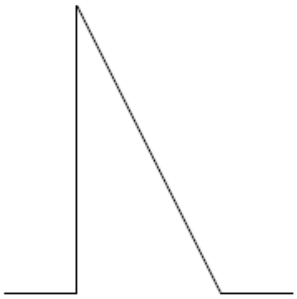


Two pulses are travelling towards each other.

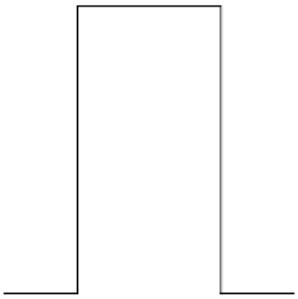


What is a possible pulse shape when the pulses overlap?

A.

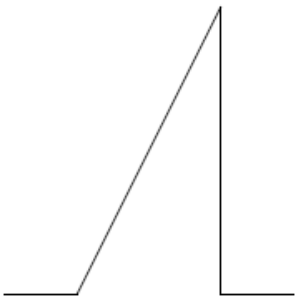


B.

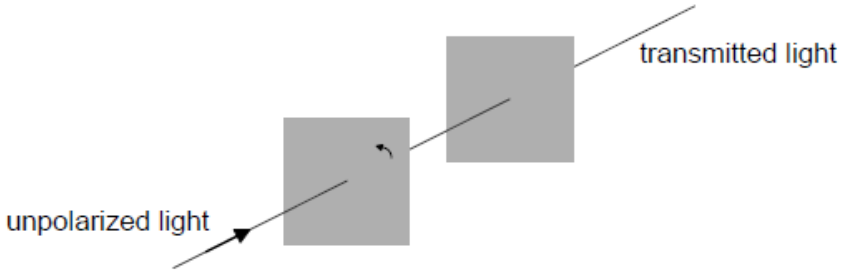


C.

D.



A beam of unpolarized light is incident on the first of two parallel polarizers. The transmission axes of the two polarizers are initially parallel.

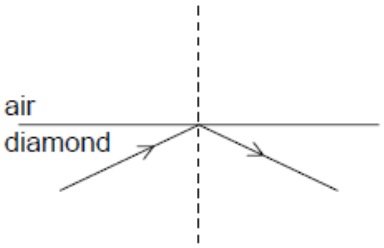


The first polarizer is now rotated about the direction of the incident beam by an angle smaller than 90°. Which gives the changes, if any, in the intensity and polarization of the transmitted light?

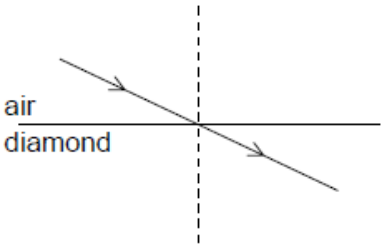
	Intensity	Polarization
A.	different	no change
B.	different	different
C.	no change	no change
D.	no change	different

A light ray is incident on an air–diamond boundary. The refractive index of diamond is greater than 1. Which diagram shows the correct path of the light ray?

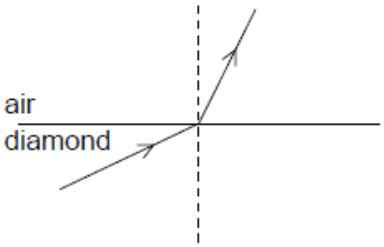
A.



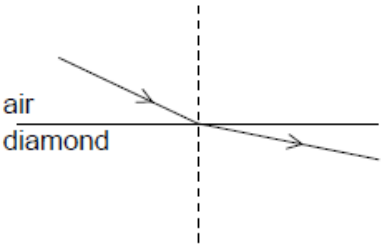
B.



C.



D.



Unpolarized light of intensity I_0 is incident on the first of two polarizing sheets. Initially the planes of polarization of the sheets are perpendicular.

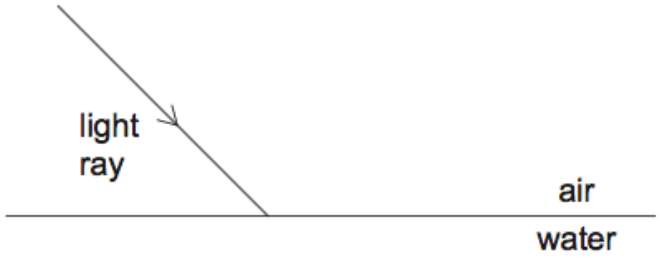
Which sheet must be rotated and by what angle so that light of intensity $\frac{I_0}{4}$ can emerge from the second sheet?

	Rotated sheet	Angle of rotation
A.	1 only	$\cos^{-1}\frac{\sqrt{2}}{2}$
B.	2 only	$\cos^{-1}\frac{1}{2}$
C.	1 or 2	$\cos^{-1}\frac{\sqrt{2}}{2}$
D.	1 or 2	$\cos^{-1}\frac{1}{2}$

Which of the following electromagnetic waves has a frequency **greater** than that of visible light?

A. Ultraviolet
B. Radio
C. Microwaves
D. Infrared

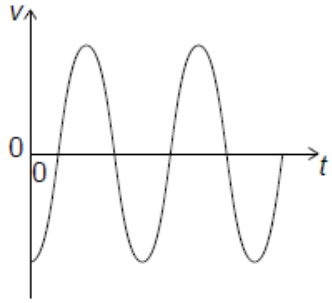
A light ray passes from air to water as shown.



What are the change in the wavelength of the light wave and the change in the angle the ray makes with the normal to the surface?

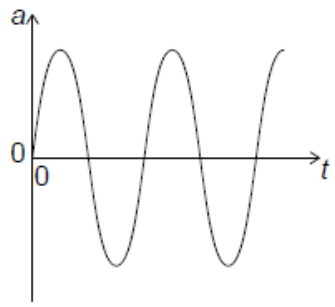
	Wavelength	Angle with normal
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

A particle undergoes simple harmonic motion (SHM). The graph shows the variation of velocity *v* of the particle with time *t*.

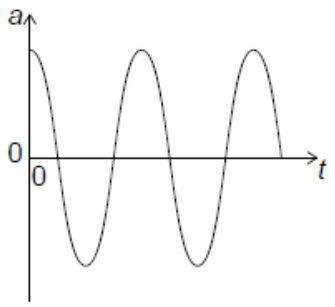


What is the variation with time of the acceleration *a* of the particle?

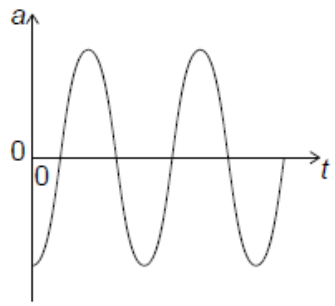
A.



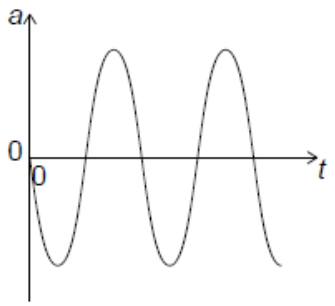
B.



C.

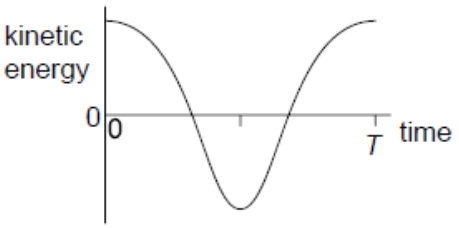


D.

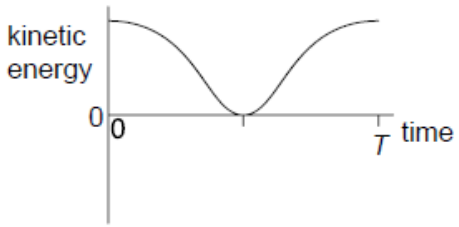


A particle oscillates with simple harmonic motion (shm) of period *T*. Which graph shows the variation with time of the kinetic energy of the particle?

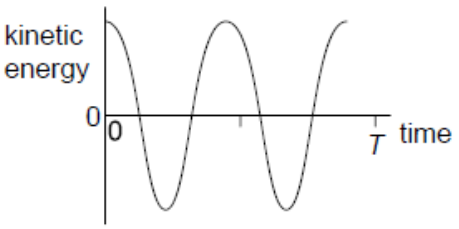
A.



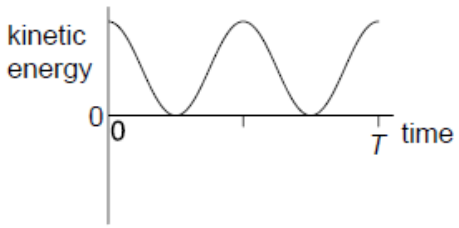
B.



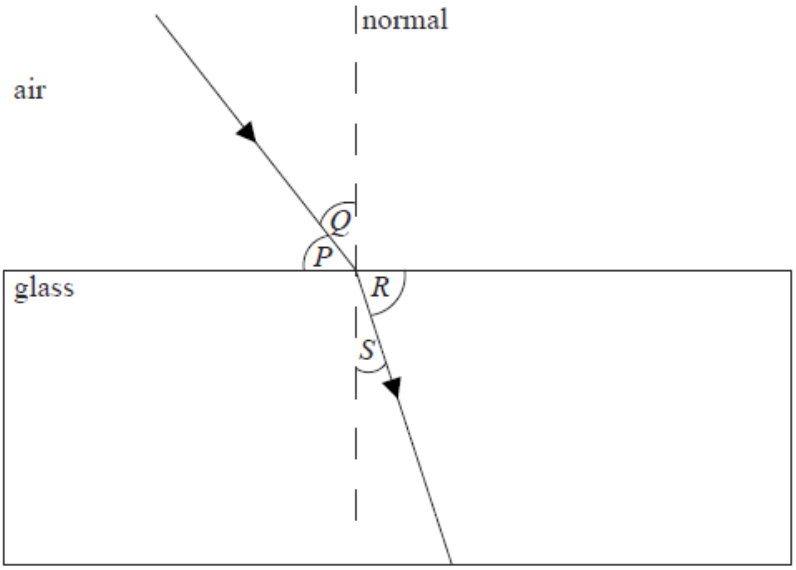
C.



D.



Light travels from air into glass as shown below.



What is the refractive index of glass?

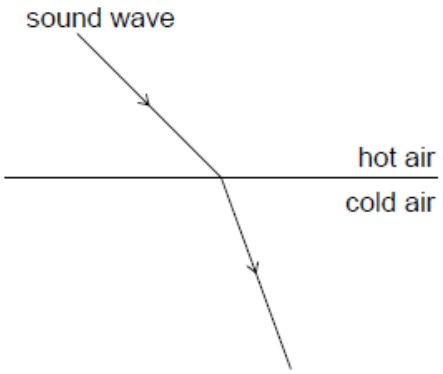
A. $\frac{\sin P}{\sin S}$

B. $\frac{\sin Q}{\sin R}$

C. $\frac{\sin P}{\sin R}$

D. $\frac{\sin Q}{\sin S}$

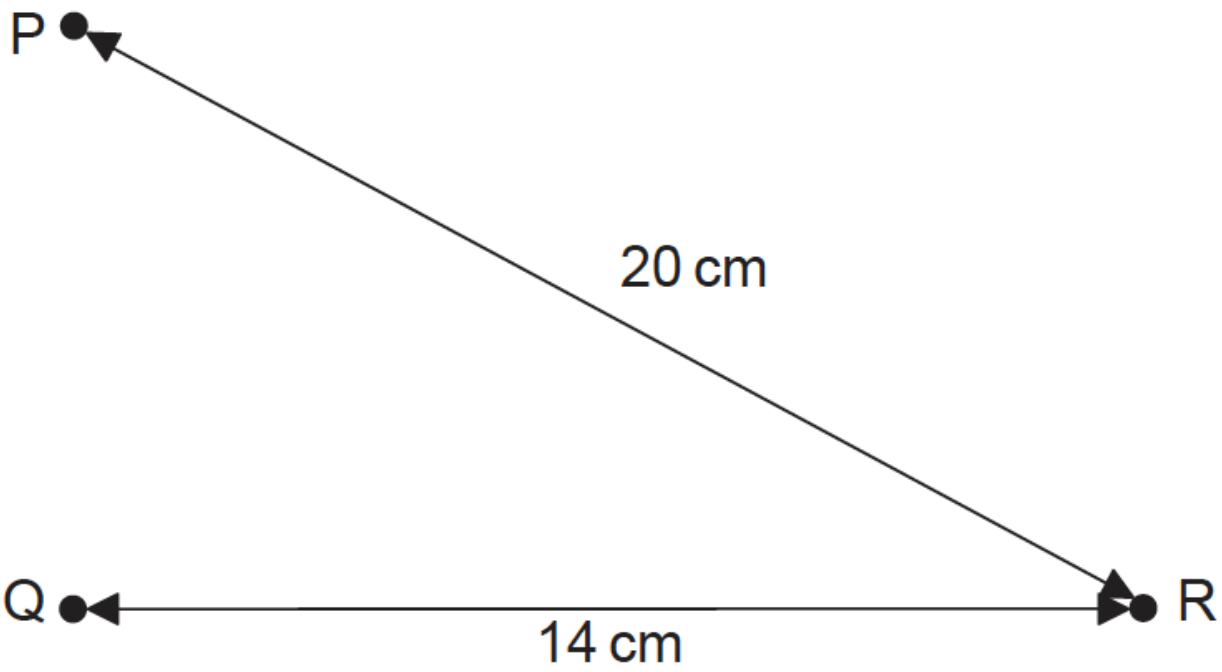
When a sound wave travels from a region of hot air to a region of cold air, it refracts as shown.



What changes occur in the frequency and wavelength of the sound as it passes from the hot air to the cold air?

	Frequency	Wavelength
A.	unchanged	increases
B.	unchanged	decreases
C.	increases	increases
D.	decreases	decreases

Wave generators placed at position P and position Q produce water waves of wavelength 4.0 cm. Each generator, operating alone, produces a wave oscillating with amplitude *A* at position R. Distances PR and QR are shown in the diagram below.



Both wave generators now operate together in phase. What is the amplitude of the oscillation of the resulting wave at R?

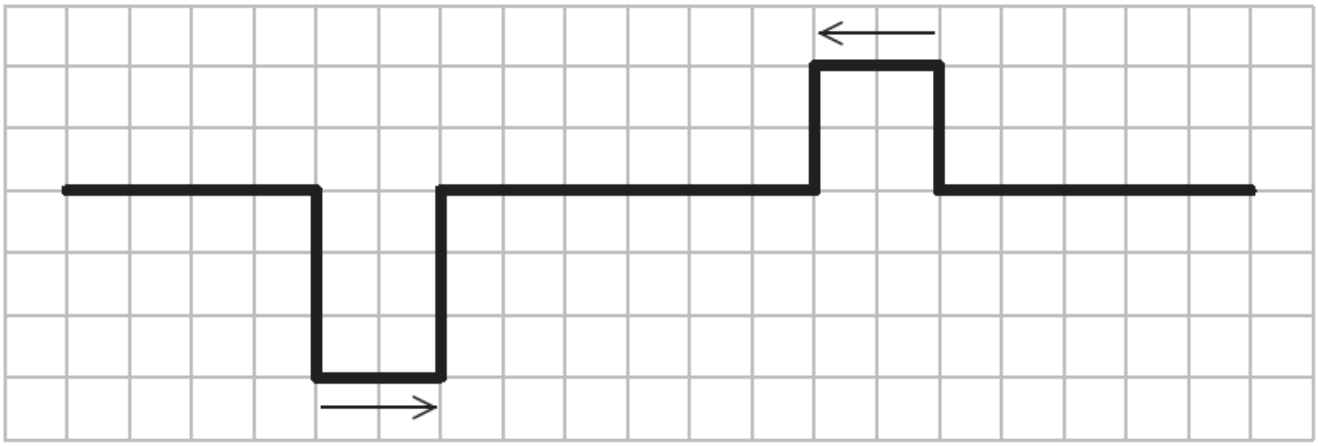
A. 0

B. *A*

C. A^2

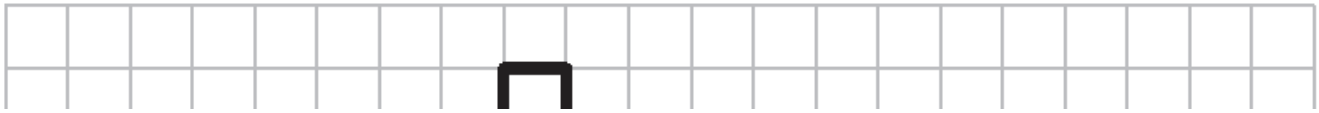
D. 2*A*

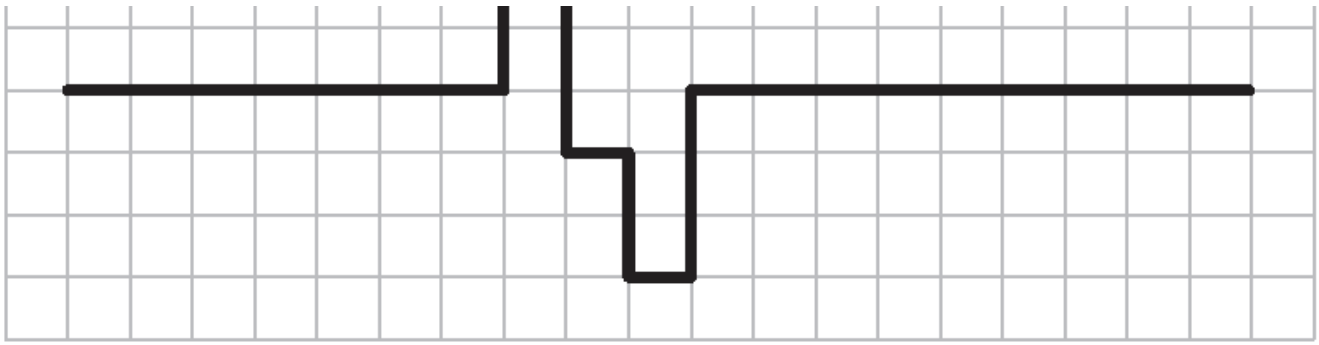
Two wave pulses move towards each other as shown in the diagram.



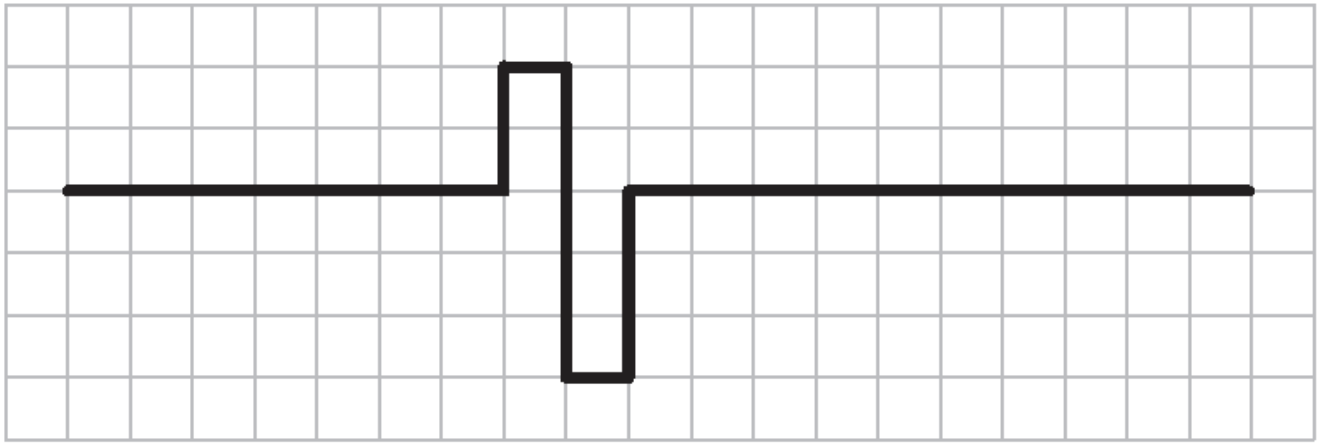
Which diagram shows a possible combination of the two pulses after a short time?

A.

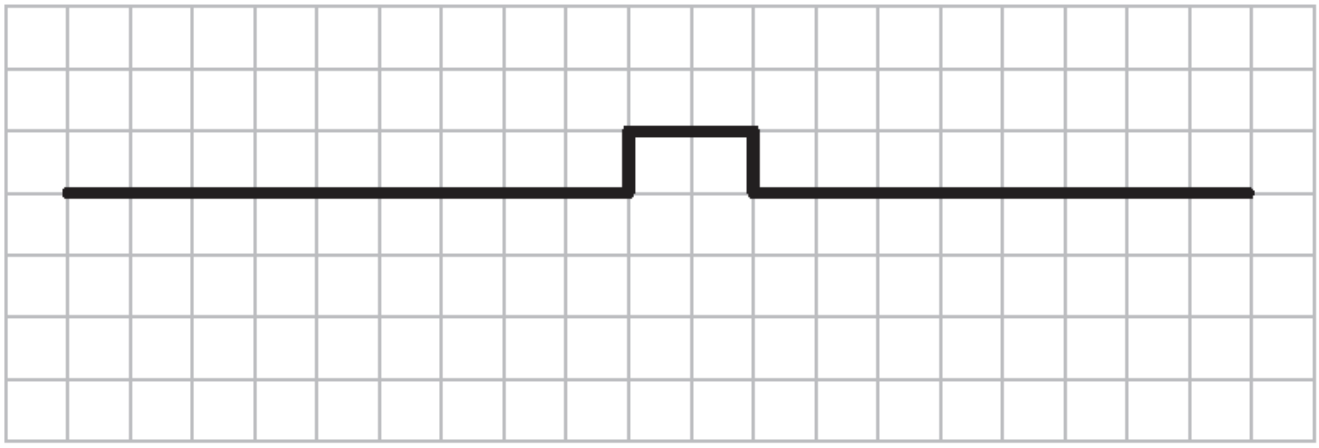




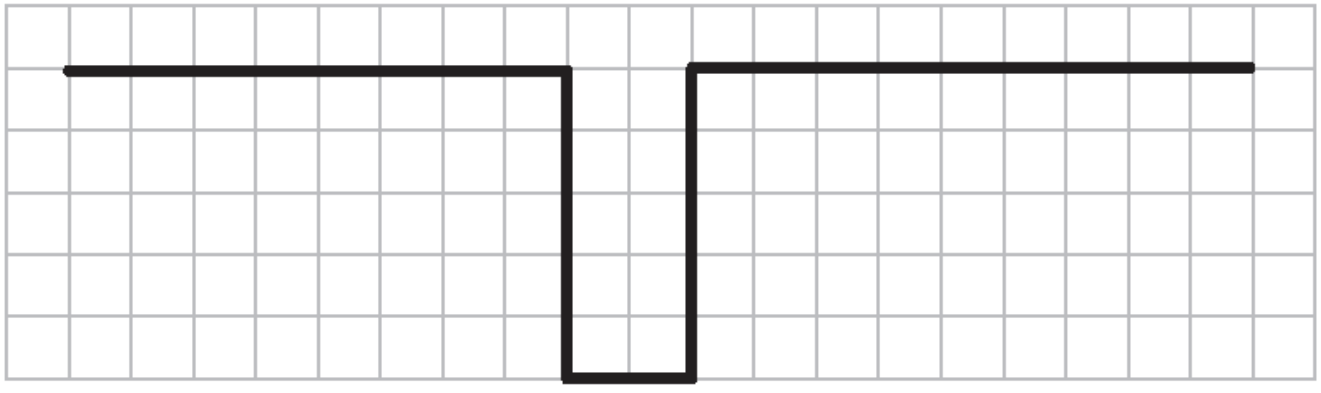
B.



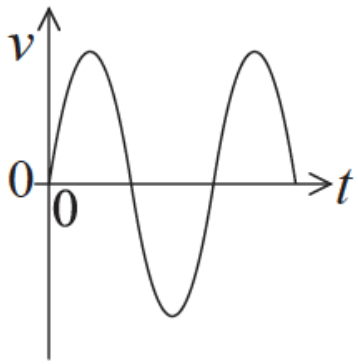
C.



D.

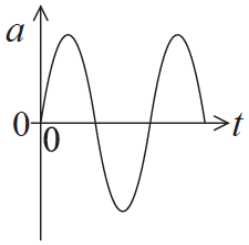


The diagram shows the variation of velocity v with time t for an object performing simple harmonic motion.

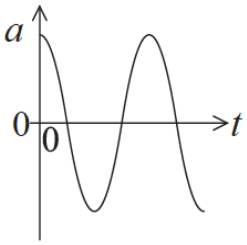


Which of the following shows how the acceleration a varies with t?

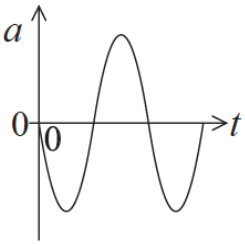
A.



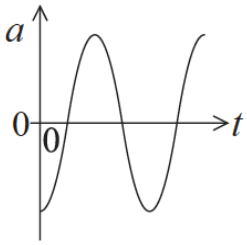
B.



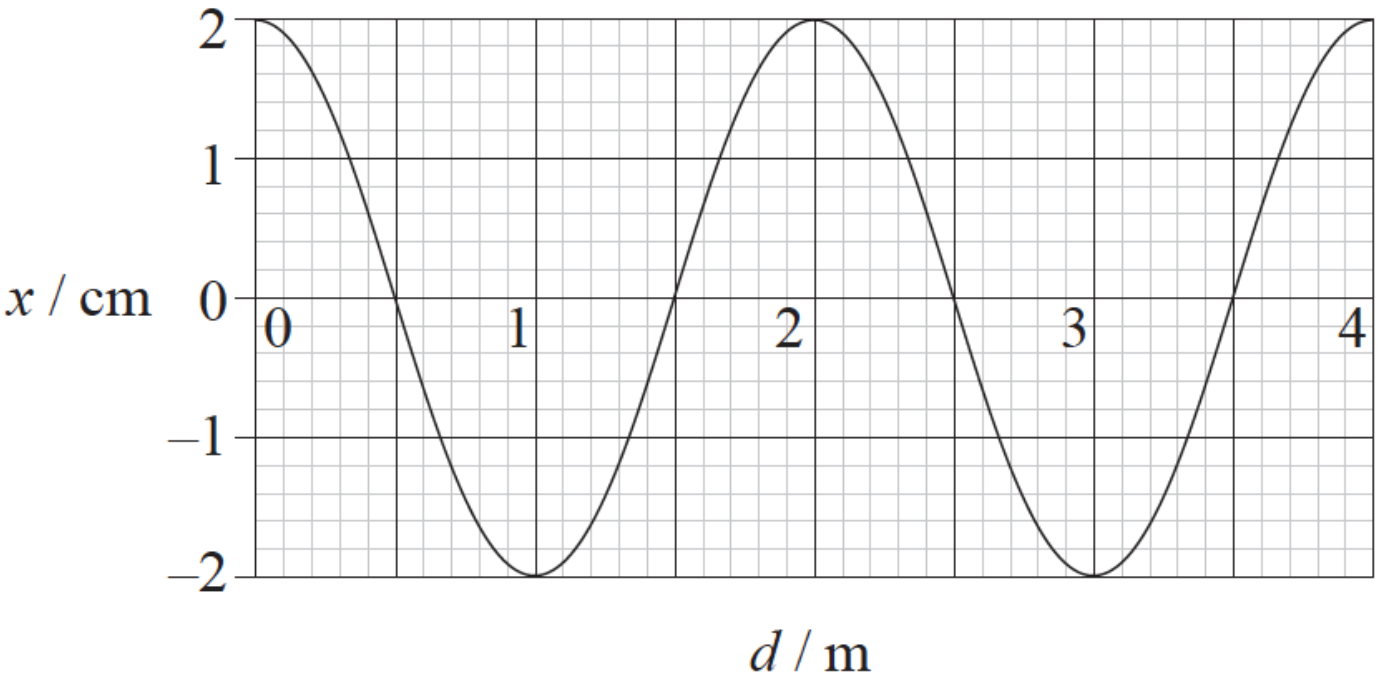
C.



D.



A wave of period 5.0m s travels through a medium. The graph shows the variation with distance d of the displacement x of points in the medium.



What is the average speed of a point in the medium during one full oscillation?

A. 0m s^{-1}
B. 4.0m s^{-1}
C. 16m s^{-1}
D. 400m s^{-1}

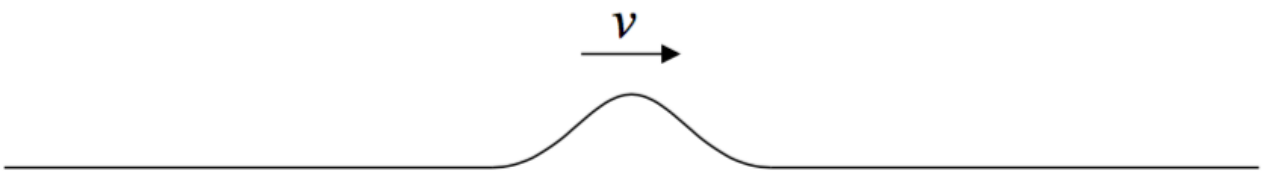
Which of the following correctly describes the direction of a ray drawn relative to a wavefront for longitudinal and transverse waves?

	Longitudinal wave	Transverse wave
A.	parallel	parallel
B.	parallel	perpendicular
C.	perpendicular	parallel
D.	perpendicular	perpendicular

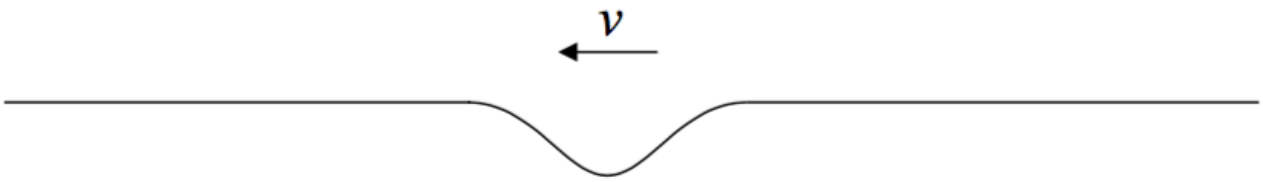
Two wave pulses travel along a string towards each other. The diagram shows their positions at a moment in time.

Which of the following shows a possible configuration of the pulses at a later time?

A.



B.

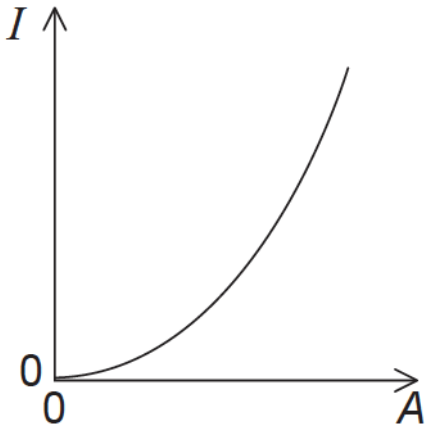


C.

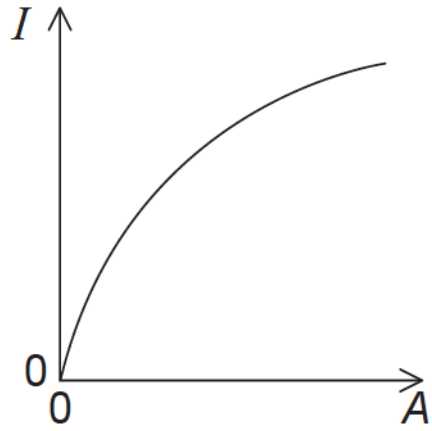
D.

Which graph shows the variation with amplitude *A* of the intensity *I* for a wave?

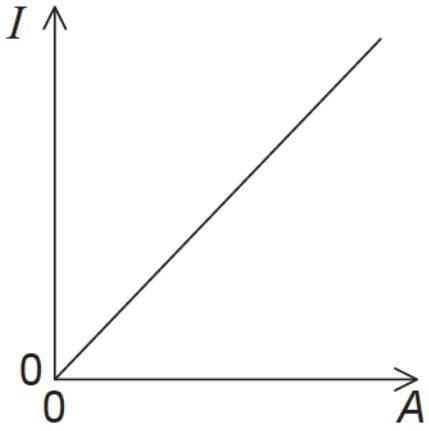
A.



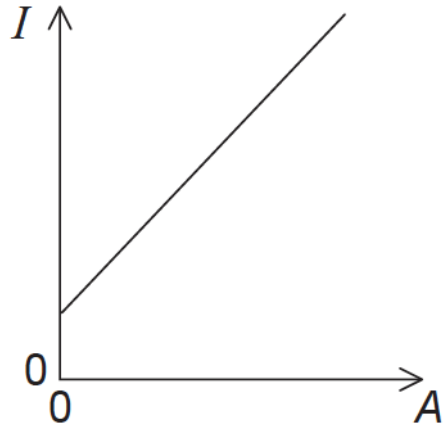
B.



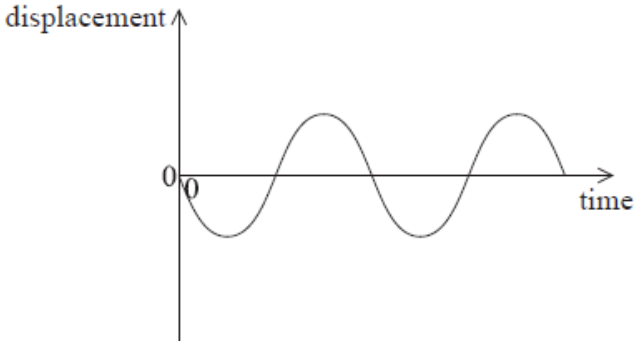
C.



D.

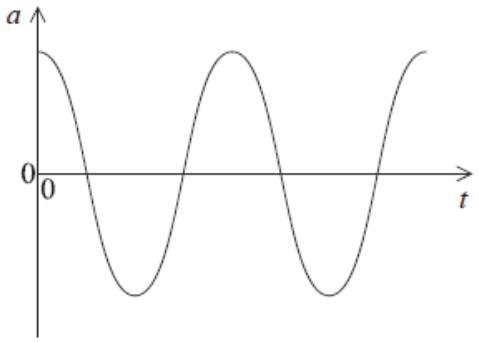


The graph shows how the displacement varies with time for an object undergoing simple harmonic motion.

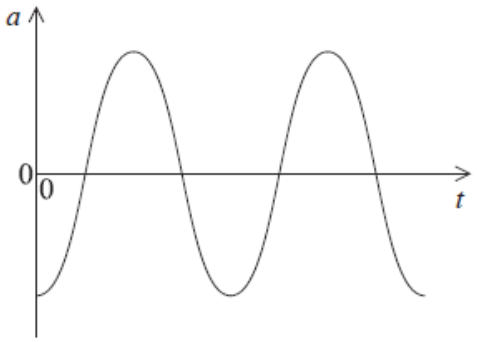


Which graph shows how the object's acceleration *a* varies with time *t*?

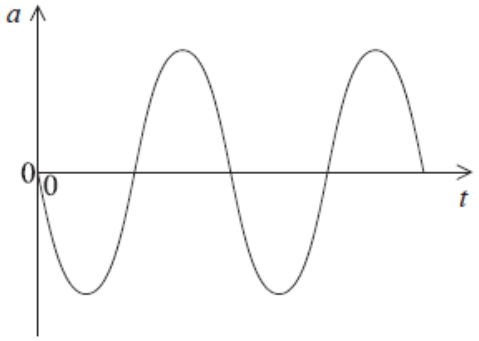
A.



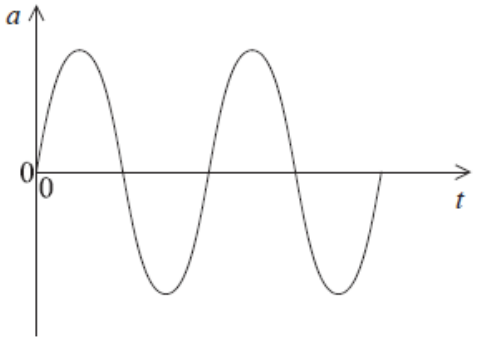
B.



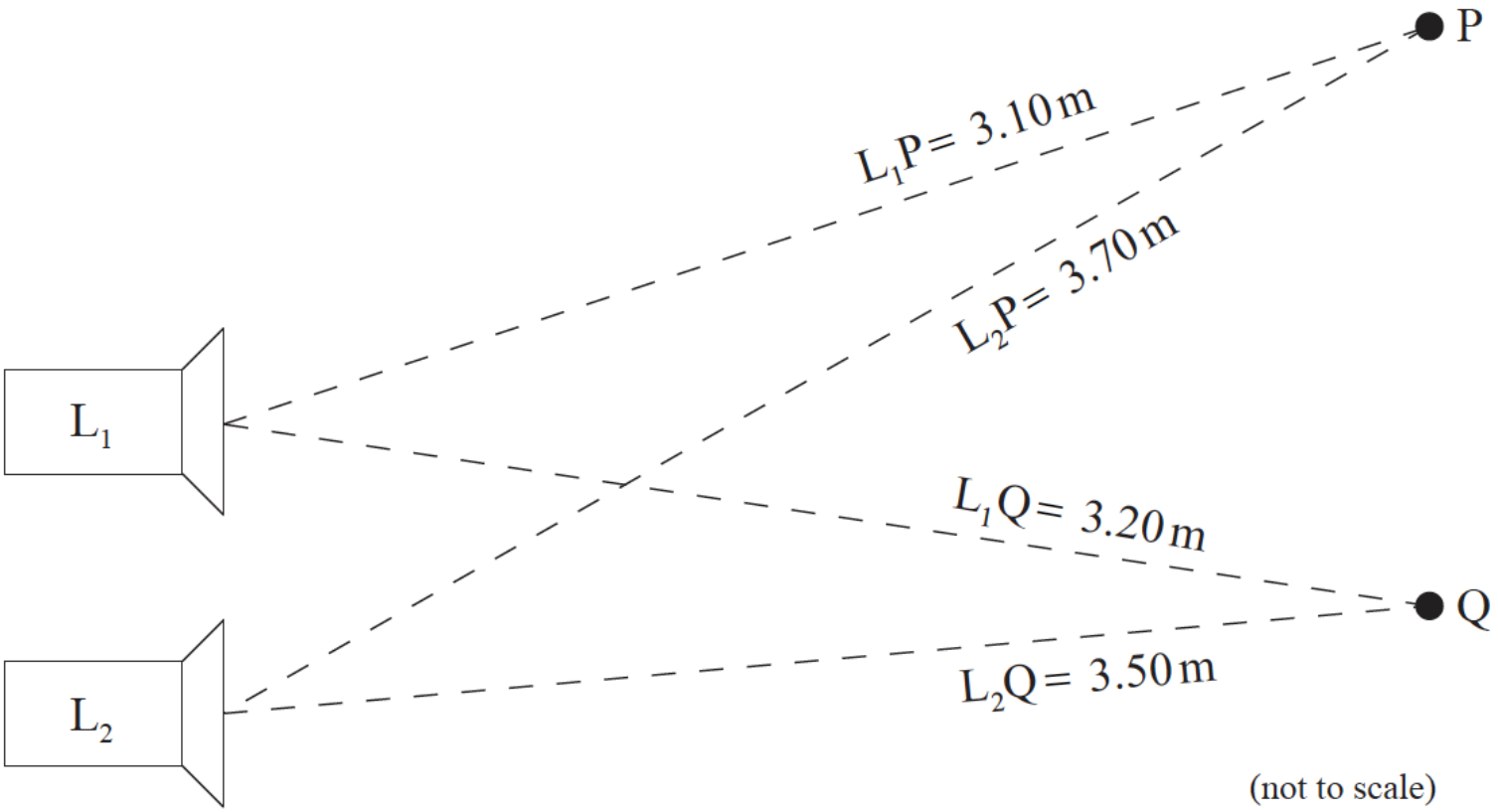
C.



D.



Two loudspeakers, L_1 and L_2, emit identical sound waves.



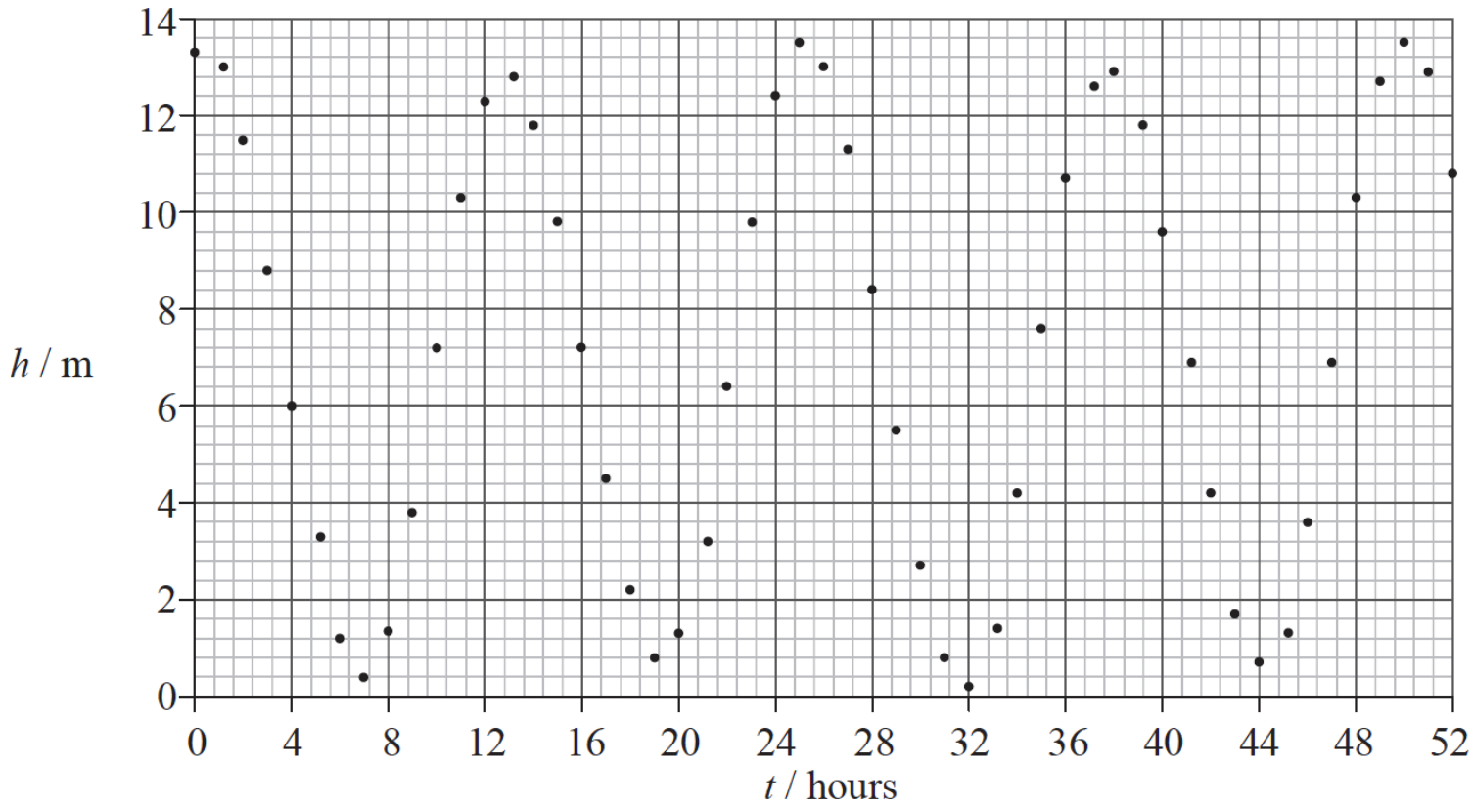
The waves leaving L_1 and L_2 are in phase and are observed at points P and Q.

The wavelength of the sound is 0.60 m. The distances of points P and Q from the loudspeakers are shown in the diagram.

Which of the following is true about the intensity of the sound at P and the intensity of the sound at Q?

	Intensity at P	Intensity at Q
A.	maximum	maximum
B.	maximum	minimum
C.	minimum	maximum
D.	minimum	minimum

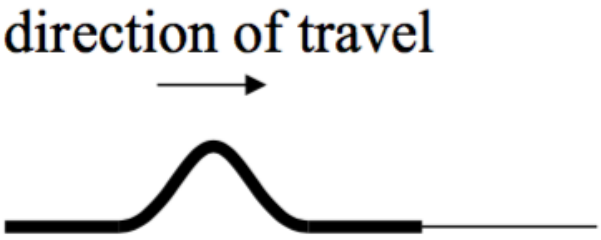
The graph shows measurements of the height h of sea level at different times t in the Bay of Fundy.



Which of the following gives the approximate amplitude and period of the tides?

	Amplitude	Period
A.	6.5 m	6 hours
B.	13 m	12 hours
C.	6.5 m	12 hours
D.	13 m	6 hours

A wave pulse is travelling along a dense thick rope which is connected to a less dense thin rope.



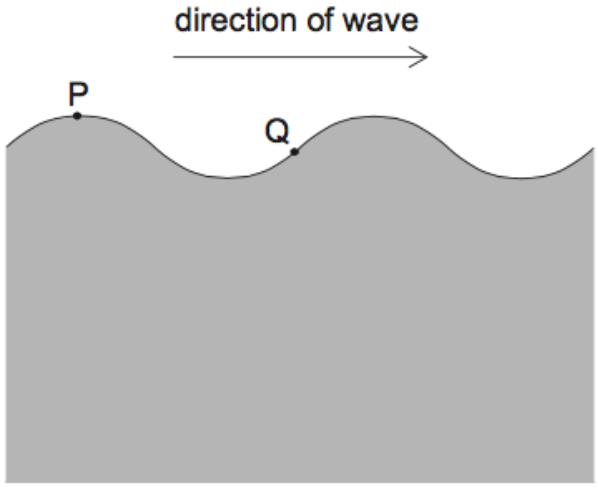
Which of the following is correct regarding the reflected and transmitted wave pulses after the wave pulse reaches the connection of the two ropes?

	Reflected pulse	Transmitted pulse
A.	inverted	inverted
B.	not inverted	inverted
C.	inverted	not inverted
D.	not inverted	not inverted

Which of the following correctly relates the direction of oscillation of the particles in a medium to the direction of energy propagation for transverse and longitudinal waves?

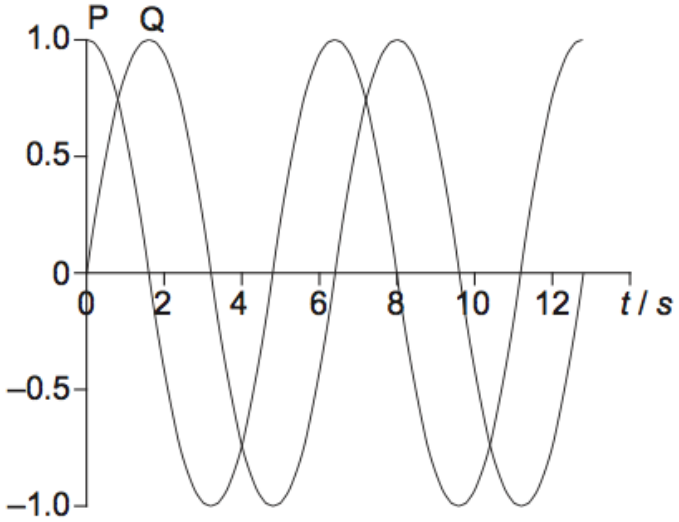
	Transverse wave	Longitudinal wave
A.	perpendicular	perpendicular
B.	perpendicular	parallel
C.	parallel	perpendicular
D.	parallel	parallel

A water wave moves on the surface of a lake. P and Q are two points on the water surface. The wave is traveling towards the right.

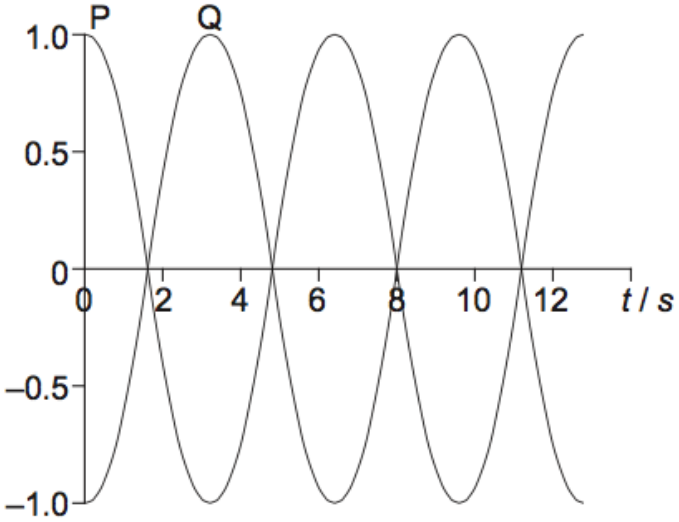


The diagram shows the wave at time $t = 0$. Which graph shows how the displacements of P and Q vary with t?

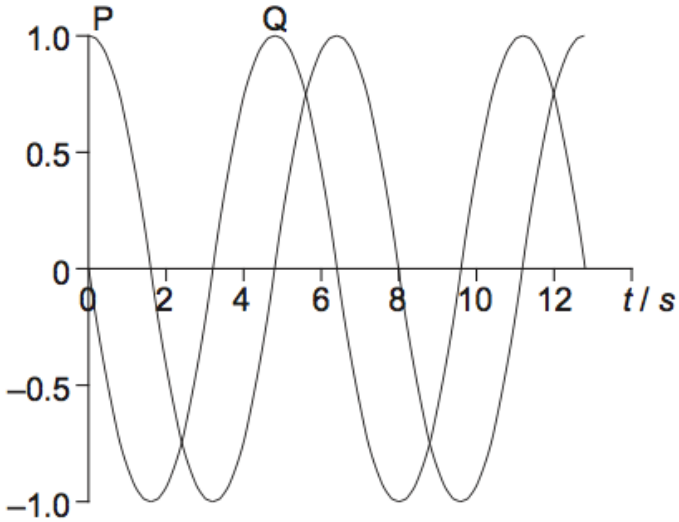
A.



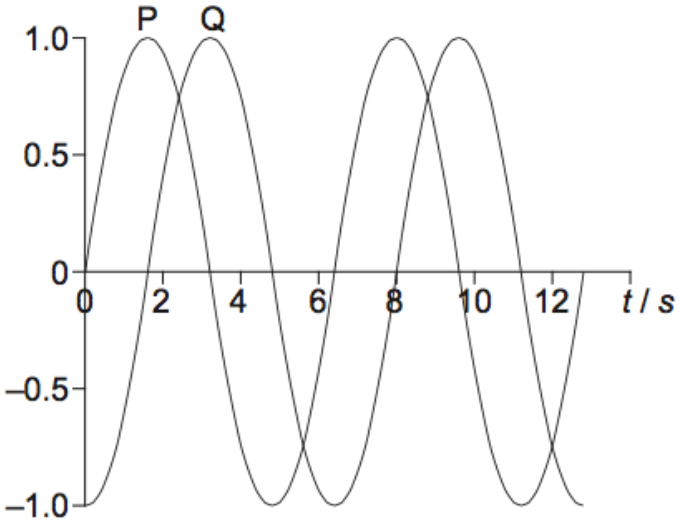
B.



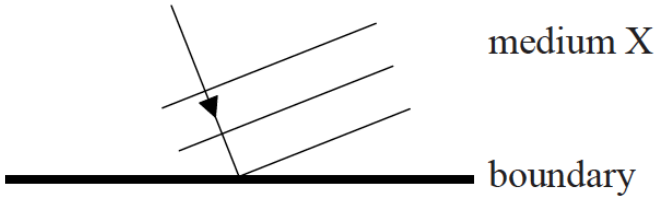
C.



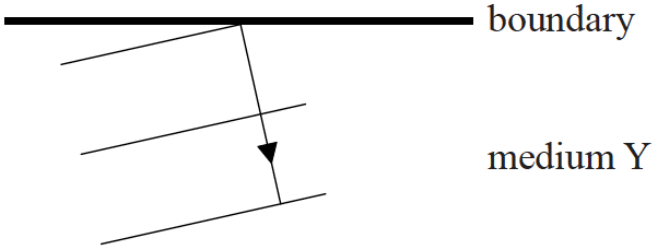
D.



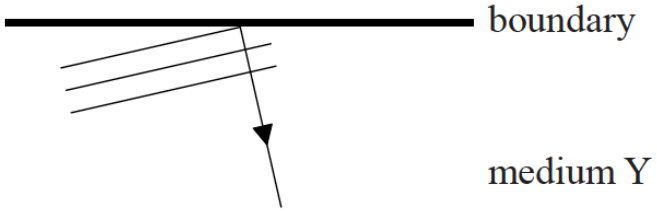
The speed of a wave in medium X is greater than the speed of the wave in medium Y. Which diagram shows the correct refraction of the wavefronts at the boundary between X and Y?



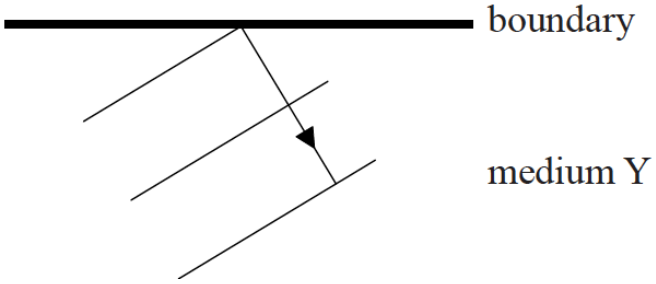
A.



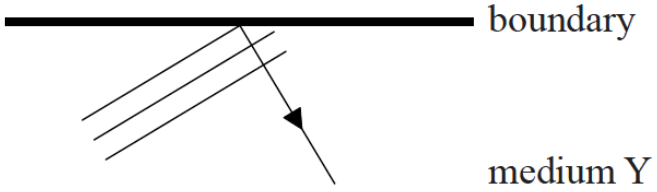
B.



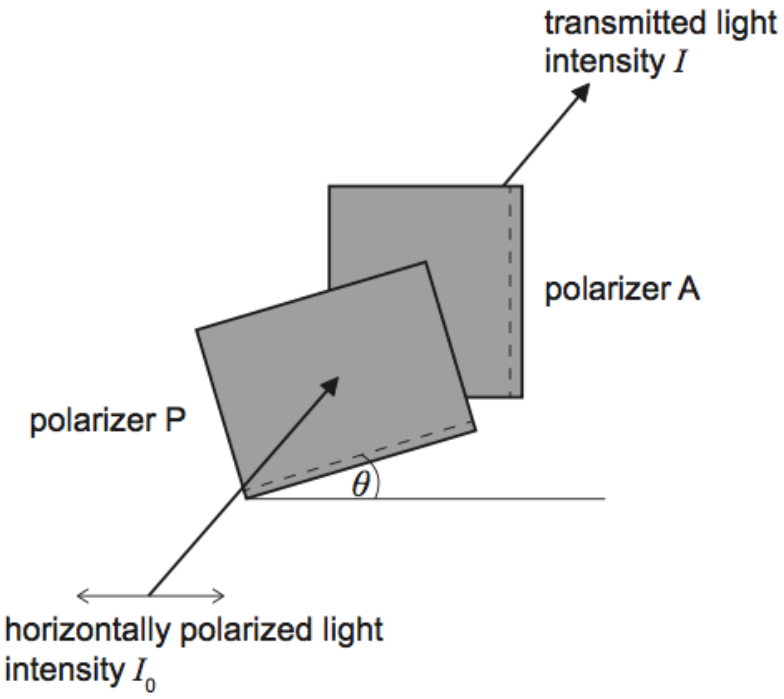
C.



D.

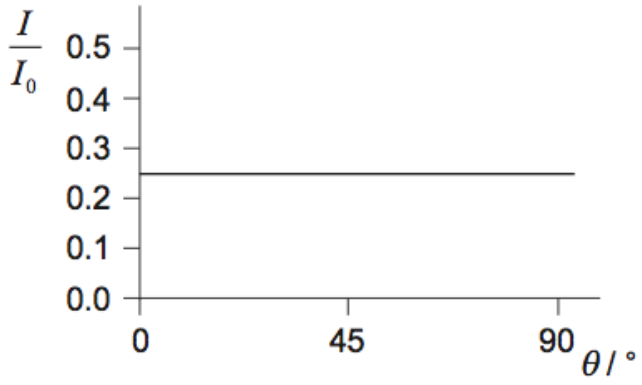


Horizontally polarized light of intensity I_0 enters a polarizer P whose polarization axis makes an angle of θ degrees with the horizontal. Light from P is then incident on a polarizer A with fixed vertical polarization axis.

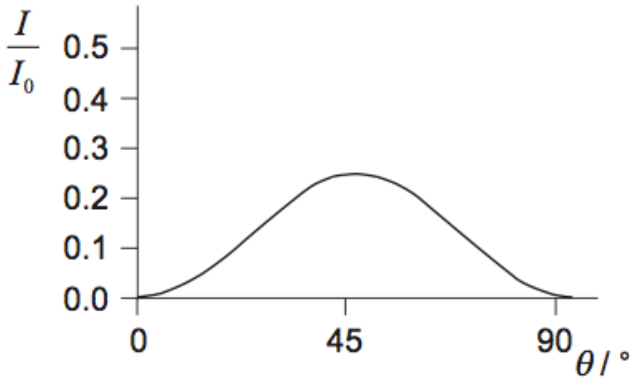


The angle θ is varied from 0 to 90 degrees. Which of the following represents the variation with θ of the intensity I of the light transmitted through A?

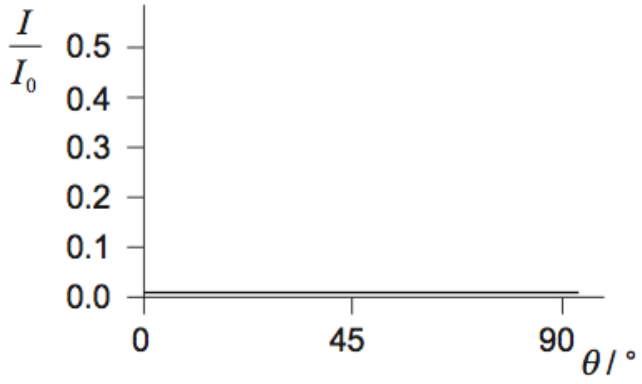
A.



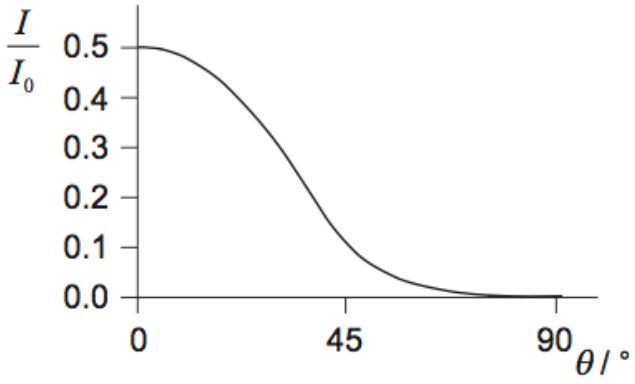
B.



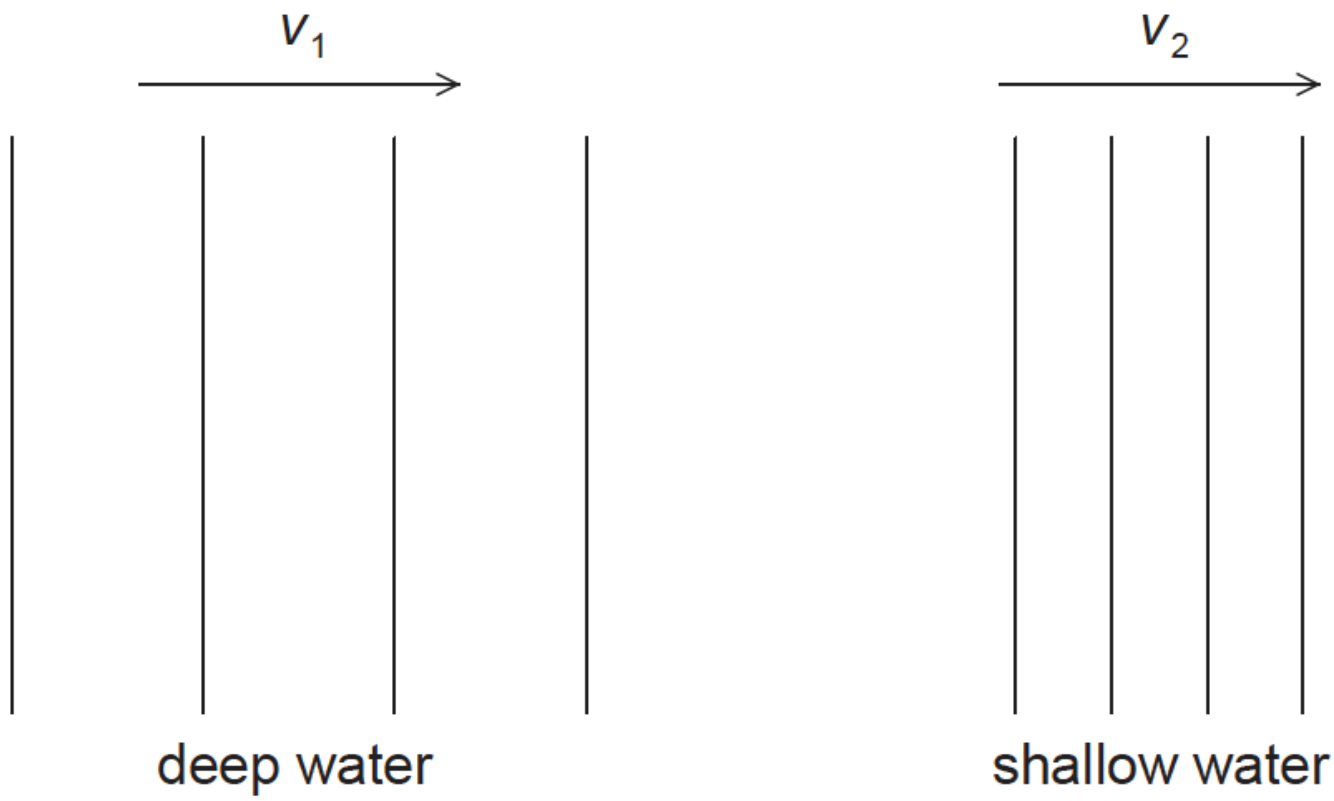
C.



D.



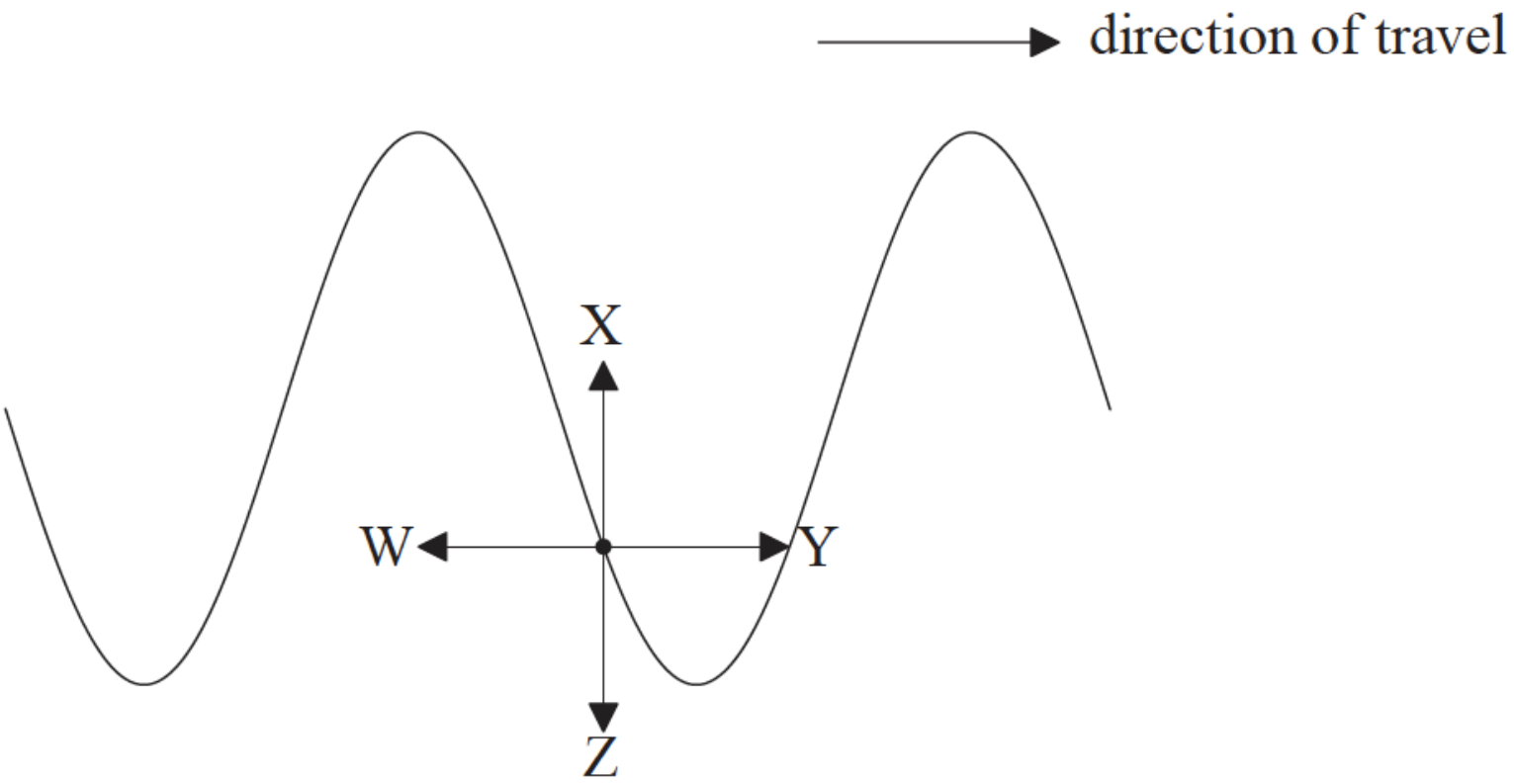
A water wave entering a harbour passes suddenly from deep to shallow water. In deep water, the wave has frequency f_1 and speed v_1. In shallow water, the wave has frequency f_2 and speed v_2.



Which of the following compares the frequencies and speeds of the wave between deep water and shallow water?

	Frequencies	Wave speeds
A.	$f_1 = f_2$	$v_1 > v_2$
B.	$f_1 = f_2$	$v_1 < v_2$
C.	$f_1 > f_2$	$v_1 = v_2$
D.	$f_1 < f_2$	$v_1 > v_2$

The diagram shows, at a particular instant in time, part of a rope along which a wave is travelling.



The wave is travelling from left to right.

Which arrow shows the direction of motion of the rope at the point shown?

A. W

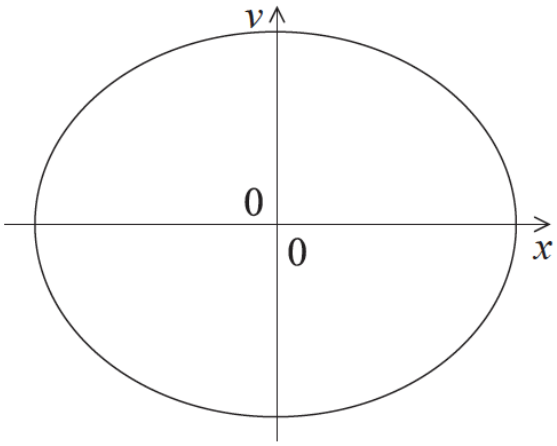
B. X

C. Y

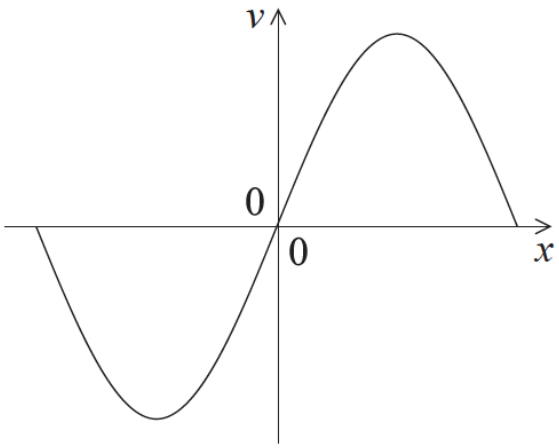
D. Z

A body undergoes simple harmonic motion. Which graph correctly shows the variation with displacement x of the velocity v of the body?

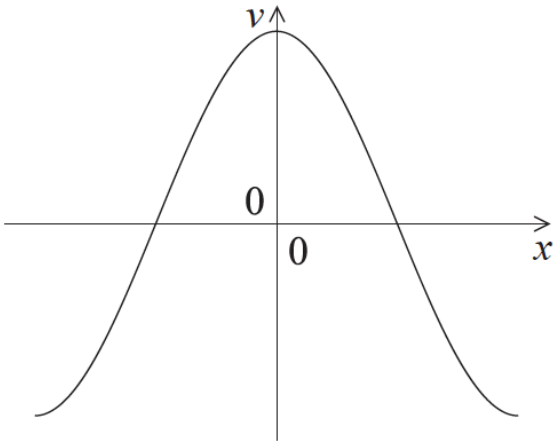
A.



B.



C.



D.